REMARKS

Status Summary

Claims 1 – 67 are pending in the present application. Claims 48 – 56 were previously withdrawn from consideration as being directed to non-elected subject matter, and are now formally canceled herein. Claims 15 and 25 – 31 were previously canceled. Claims 1 – 14, 16 – 24, 32 – 47, and 57 – 67 presently stand rejected. Claims 14, 32, 40 and 62 have been amended herein. Claim 67 has been canceled herein.

Summary of Examiner's Interview

On January 23, 2004, David Gloekler, assisting Applicants' counsel pursuant to an Associate of Power of Attorney dated December 17, 2003, conducted a telephonic interview with the Examiner. Applicants appreciate the courtesies extended by the Examiner during the interview.

During the interview, the patentability of independent claims 1, 40 and 62 were discussed in view of the two references cited by the Examiner in the above-identified Office Action, US Patent No. 6,218,280 to Kryliouk et al. (hereinafter "Kryliouk et al.") and US Patent No. 5,270,263 to Kim et al. (hereinafter "Kim et al."). Applicants' assistant argued that Kryliouk et al. and Kim et al. are not properly combinable due to the disparate approaches taken by these references toward the growth of nitrides. Applicants' arguments regarding the combinability of

Kryliouk et al. and Kim et al. are set forth in more detail hereinbelow in response to the rejection of the claims.

Regarding claim 1, Applicants' assistant argued that (1) Kryliouk et al. do not disclose a sputtering technique, and that (2) Kim et al. disclose only the growth of a thin film of a Group III nitride, no more than 1000 Å (Angstroms) in thickness. During the interview, the Examiner indicated that claim 1 was allowable.

Regarding claim 40, the Examiner indicated that claim 40 would be allowable if the thickness feature of claim 1 were added, or if the subject matter of claims 44, 45 or 46 were added. Accordingly, claim 40 has been amended herein to recite the thickness feature of claim 1.

Regarding claim 62, the Examiner indicated that claim 62 would be allowable if the thickness feature of claim 1 were added, or if the subject matter of claims 63, 64 or 65 were added. Accordingly, claim 62 has been amended herein to recite the thickness feature of claim 1.

In view of the foregoing, it is believed that claims 1, 40 and 62, as well as all claims depending therefrom, are allowable at this time.

Claim Rejections - 35 U.S.C. § 103

Claims 1 – 14, 16 – 24, 32- 47, and 57 – 67 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Kryliouk et al. in view of Kim et al. and Background of Invention. Applicants respectfully traverse the rejection because no suggestion or motivation has been shown for modifying or combining the cited

references as proposed by the Examiner, with any reasonable expectation of success, and the cited references in combination fail to teach or suggest all the features or elements recited in each of the rejected claims.

In the present Office Action, the Examiner concedes that Kryliouk et al. fail to teach the step of sputtering a Group III metal target in a plasma-enhanced environment to produce a Group III metal source vapor. The Examiner contends, however, that such is taught by Kim et al. The Examiner concludes that "[i]t would have been obvious to one having ordinary skill in the art at the time of the present invention to apply the teachings of Kim and BOI into the method of Kryliouk as both are related to the same subject matter of producing large area single crystalline III-IV [sic: III-V] nitride compound semiconductor substrate having sputtering metal target with nitrogen containing plasma in a plasma enhanced chemical vapor deposition (PECVD)."

As an initial matter, Applicants respectfully submit that the respective methods of Kryliouk et al. and Kim et al. do not relate to the same subject matter, but rather quite divergent subject matter. Kryliouk et al. teach starting with a $LaGaO_2$ (lithium gallate) substrate, growing a thin film of GaN (gallium nitride) on the $LaGaO_2$ substrate by means of MOVPE (metal organic vapor phase epitaxy), and then growing a bulk film of GaN on the thin-film MOVPE GaN by means of MOVPE, HVPE (hydride vapor phase epitaxy), or a hybrid process of MOVPE and HVPE. *See* Kryliouk et al., col. 6, lines 15-67 to col. 7, lines 1-23. This technique requires the use of gaseous precursors to provide sources for gallium and

nitrogen. As disclosed by Krylіouk et al., TMG (trimethylgallium) gas is first reacted with HCl (hydrochloric acid) to form a stream of GaCl (gallium chloride) species, which is then combined with NH_3 (ammonia) gas in a downstream mixing zone and passed over the $LaGaO_2$ substrate to deposit GaN thereon. *See* Krylіouk et al., col. 7, lines 1-23; and col. 12, lines 14-31. To produce the structure shown in Figure 1B of Krylіouk et al., thin-film GaN is grown by MOVPE and followed by a bulk GaN layer grown by HVPE. *See* Krylіouk et al., col. 7, lines 52-60.

Krylіouk et al. nowhere teach any form of a sputtering technique for growing either III-V thin films or III-V bulk layers. Moreover, Krylіouk et al. teach the use of process equipment specifically and exclusively designed for the handling of CVD (chemical vapor deposition) based processes or CVD related processes, and nowhere suggest that their techniques or equipment could be modified to effect sputtering or any other type of PVD (physical vapor deposition) related processes.

Kim et al. teach the entirely different technique of deposition of AlN by nitrogen plasma sputtering. In fact, Kim et al. expressly distinguish prior art methods that use process gases such as NH_3 and chlorinated Group III metals. *See* Kim et al., col. 1, lines 65-68 to col. 2, lines 1-17. Thus, Kim et al. teach away from the processes taught by Krylіouk et al., and it would therefore be unreasonable to expect a person skilled in the art to apply the teachings of Kim et al. to the method of Krylіouk et al. as contended by the Examiner. Moreover, the process equipment taught by Kim et al. could not be expected to be successfully

integrated with the process equipment taught by Kryliouk et al. In their Figure 2, Kim et al. teach the use of a vacuum chamber (32) containing a solid Al target (36) and a semiconductor wafer (38). N_2 (nitrogen) gas is introduced into the vacuum chamber (32) and ionized. As a result, nitrogen atoms are attracted to the Al target (36), accelerate toward the Al target (36), and physically strike the Al target (36). As a result, aluminum atoms are released from the Al target (36), enabling them to combine with nitrogen molecules and form a thin-film of AlN on the surface of the wafer (38). *See* Kim et al., col. 4, lines 38-57. Furthermore, the disclosure of Kim et al. is directed entirely to the production of thin films, while the disclosure of Kryliouk et al. is directed to the production of a GaN layer of bulk thickness. The thickest nitride film disclosed by Kim et al. is only 1000 Å (Angstroms), or 0.1 micron, which would generally be considered to be a thin film by persons skilled in the art. *See* Kim et al., col. 5, line 5 and col. 6, line 24. Therefore, it would not be reasonable to consider a technique for growing a thin film by PVD as being applicable for modifying or enhancing a technique for growing a bulk film by CVD, MOVPE, or HVPE.

Second, neither Kryliouk et al. nor Kim et al. relate to a plasma enhanced chemical vapor deposition (PECVD) process as contended by the Examiner. The technique disclosed by Kryliouk et al. relies on the use of a hot-wall reactor and/or preheated gas-phase chemistries to provide thermal energies to drive their desired reaction kinetics. Kryliouk et al. do not disclose the generation of plasma as a mechanism for energy input or as an enhancement to their process. On the other

hand, Kim et al. disclose a plasma-enhanced process, but this process is a PVD process and not a CVD process. It should also be noted that the present application would not be considered as relating to a PECVD process because, like Kim et al., the present application is directed to a plasma enhanced sputtering technique.

Claims 1 – 14, 16 – 24, 37 – 39, and 57 - 61:

Turning now to the claims of the present application, claim 1 is directed to a "method for producing a single-crystal $M^{III}N$ article". Claim 1 recites "sputtering a Group III metal target" and "depositing the reactant vapor species on the growth surface to produce a single-crystal $M^{III}N$ layer thereon having a thickness of greater than approximately 10 microns." During the above-identified Examiner's interview, the Examiner indicated that claim 1 is allowable as currently presented. Accordingly, claim 1 is believed to be in condition for allowance at this time.

In addition, Kryliouk et al. fail to teach any form of a sputtering process to produce a single-crystal $M^{III}N$ layer having a thickness of greater than approximately 10 microns. Kryliouk et al. rely solely on an MOVPE and/or HVPE process. Kryliouk et al. fail to suggest or provide any motivation for modifying their disclosed process to carry out a sputtering technique such as that disclosed in Kim et al. Kryliouk et al. fail to suggest or provide any motivation for substituting a sputtering methodology for their vapor phase epitaxy methodology to provide a Group III metal in a form and in a reactor environment that would result the

successful growth of a Group III nitride compound having a thickness of approximately 10 microns or greater. At the time of their disclosure, Kryliouk et al. recognized that "*bulk GaN substrates are not available currently*" (Kryliouk et al., col. 1, lines 32-33 & 63-64), and that "*no one has succeeded in making large bulk GaN single crystal substrates*" (Kryliouk et al., col. 2, lines 48-49). Kryliouk et al. purport to provide a solution by employing a technique that requires a series of chemical reactions of gaseous precursors and intermediate species that are driven by thermal energy, and not through the use of a sputtering technique.

On the other hand, the teaching of Kim et al. entails a chemical reaction only insofar as nitrogen gas molecules react with liberated Al atoms with the result that an AlN compound is deposited on a wafer. However, in great contrast to Kryliouk et al., Kim et al. require ionization, transport, and dislodging of atoms by physical, collisional impact driven by a plasma discharge, and then synthesis. Therefore, given the disparities between their respective techniques, it would not be reasonable to expect that the teaching of Kim et al. could be applied to that of Kryliouk et al.

Moreover, Kim et al. teach only the conventional use of sputtering to grow a thin (e.g., 1000 Å) film, and do not appear to teach the growth of a single crystal material. As is well known by persons skilled in the art, the fact that a given technique is successful in growing a polycrystalline thin film does not also suggest that the technique would be equally successful in growing a single crystal material of any industry-accepted quality (e.g., defect density, purity, level of stress or

strain, etc.) due to the major differences in processing conditions and equipment design. As also is well known by persons skilled in the art, the fact that a given technique is successful in growing a thin film of any type does not also suggest that the technique would be equally successful in growing a bulk layer of any practical utility or industrial applicability, or of an industry-accepted quality (e.g., defect density, purity, level of stress or strain, monocrystalline, etc.) needed in the fabrication of microelectronic devices. Nowhere in their disclosure do Kim et al. suggest that their technique could be employed to grow single-crystal AlN or bulk AlN, or to enhance an MOVPE- or HVPE-based process such as disclosed in Kryliouk et al.

Claims 2 – 14, 16 – 24, 37 – 39, and 57 – 61 depend or ultimately depend from claim 1, and therefore are patentable over the combined disclosures of Kryliouk et al. in view of Kim et al. and Background of Invention, at least for the same reasons as regards claim 1.

Claims 40 – 47, 66 and 67:

Independent claim 40 directed to a "method for producing a single-crystal $M^{III}N$ article". As a result of the above-identified Examiner's Interview, claim 40 has been amended to recite "depositing the reactant vapor species on the growth surface to produce a single-crystal $M^{III}N$ layer thereon having a thickness of greater than approximately 10 microns." Accordingly, claim 40 as amended is believed to be in condition for allowance at this time.

In addition, claim 40 recites "using a sputtering apparatus comprising a non-thermionic electron/plasma injector assembly to produce a Group III metal source vapor from a Group III metal target". Krylioukk et al. and Kim et al. fail to teach the use of a sputtering apparatus comprising a non-thermionic electron/plasma injector assembly. As discussed hereinabove, Krylioukk et al. fail to teach any type of a sputtering apparatus. The disclosure of Kim et al. teach only the use of a conventional sputtering apparatus, and thus represents technology of the prior art that Applicants specifically distinguished in the present application. *See* Kim et al., col. 2, lines 67-68 to col. 3, lines 1-3 ("with the process of the invention an aluminum nitride (AlN) film is deposited *in a conventional sputtering apparatus*"). Referring to Figure 2 of Kim et al. and the written description pertaining thereto, Kim et al. clearly fail to disclose any means for providing auxiliary electrons and/or plasma into their reaction space, whether thermionically or non-thermionically. Thus, while both claim 40 and Kim et al. provide a plasma discharge as part of a sputtering technique, Kim et al. fail to provide the additional step of utilizing a non-thermionic injector assembly as an additional source of electrons and/or plasma. Moreover, neither Krylioukk et al. nor Kim et al. suggest that a non-thermionic injector assembly or any other auxiliary electron and/or plasma source could be employed to enhance their process.

Claims 41 – 47 and 66 depend or ultimately depend from claim 40, and therefore are patentable over the combined disclosures of Krylioukk et al. in view of

Kim et al. and Background of Invention, at least for the same reasons as regards claim 40.

Claim 67 has been canceled in view of the amendment made to claim 40, and thus the rejection to claim 67 is moot.

Claims 62 – 65 and 32 – 36:

Independent claim 62 directed to a "method for producing a single-crystal $M^{III}N$ article". Claim 62 recites "sputtering a Group III metal target in a plasma-enhanced environment to produce a Group III metal source vapor". In addition, as a result of the above-identified Examiner's Interview, claim 62 has been amended to recite "using the single-crystal $M^{III}N$ layer as a seed crystal to grow a bulk $M^{III}N$ layer having a thickness of greater than approximately 10 microns by depositing additional reactant vapor species comprising a Group III metal and nitrogen on the seed crystal." Accordingly, claim 62 as amended is believed to be in condition for allowance at this time.

Claims 63 – 65 and 32 – 36 depend or ultimately depend from claim 62, and therefore are patentable over the combined disclosures of Kryliouk et al. in view of Kim et al. and Background of Invention, at least for the same reasons as regards claim 62.

Conclusion as to claims 1 – 14, 16 – 24, 32- 47, and 57 – 66:

In view of the foregoing, Applicants respectfully submit that claims 1 – 14, 16 – 24, 32- 47, and 57 – 66 are patentable under 35 U.S.C. § 103(a) over the combined disclosures of Krylіouk et al. in view of Kim et al. and Background of Invention, and therefore request that the rejection to claims 1 – 14, 16 – 24, 32-47, and 57 – 66 be withdrawn at the earliest time possible.

Other Claim Amendments

Claims 14 and 32 have been amended to change the spelling of "metallorganic" to "metalorganic". The amendments to claims 14 and 32 are not made in response to a substantive rejection or for any purpose believed to relate to patentability.

CONCLUSION

In light of the above amendments and remarks, it is respectfully submitted that the present application is now in proper condition for allowance, and an early notice to such effect is earnestly solicited.

If any small matter should remain outstanding after the Patent Examiner has had an opportunity to review the above Remarks, the Patent Examiner is respectfully requested to telephone the undersigned patent attorney in order to resolve these matters and avoid the issuance of another Official Action.

Serial No.: 09/998,080

DEPOSIT ACCOUNT

The Commissioner is hereby authorized to charge any fees associated with the filing of this correspondence to Deposit Account No. **50-0426**.

Respectfully submitted,

JENKINS, WILSON & TAYLOR, P.A.

Date: 2-2-04

By: Richard E. Jenkins

Richard E. Jenkins
Registration No. 28,428

297/105/2 REJ/EEM/cht

Customer No: 25297